EPA CONTRACT NO. 68-W6-0042
EPA WORK ASSIGNMENT NO. 046-FRFE-0116

EPA Project Officer: Diana King
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FINAL
SECOND FIVE-YEAR REVIEW
FOR THE
CHARLES GEORGE LAND RECLAMATION TRUST LANDFILL SUPERFUND SITE

Operable Units 1, 2, 3, and 4
Tyngsborough, Massachusetts

March 2000

Prepared by:

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M&E
AQUA ALLIANCE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION I
ONE CONGRESS STREET, SUITE 1100, BOSTON, MASSACHUSETTS 02114-2023

MEMORANDUM

DATE: March 21, 2000

SUBJ: **The Charles George Landfill Superfund Site:** Final Second Five Year Review

FROM: Patricia L. Meaney, Director
Office of Site Remediation and Restoration

TO: File

The second Five Year Review for the Charles George Land Reclamation Trust Landfill (Site) was completed in March 2000. EPA contracted Metcalf & Eddy, Inc. to prepare the report. M&E also prepared the first Five Year Review and the final report was submitted in August 1995.

When the first five year review was conducted, construction of Operable Units 3 and 4 (OU 3 and 4) (Management of Migration) was not complete. The first five year, did however, determine that Operable Units 1 (municipal waterline extension) and 2 (source control cap construction) were protective. Construction of operable Units 3 and 4 was completed in September 1998. Therefore, all remedies implemented at the site could be evaluated in the second five year review.

The report surmises that all four operable units are or remain protective of human health and the environment. The major findings and recommendations include:

1) that the original waterline is still in service (OU 1);

2) the cap continues to provide protectiveness (OU 2), however, improvement of cap maintenance is needed, specifically better control of vegetative growth on the cap (State O&M responsibility);

3) landfill gas emissions meet target cleanup levels, however, suggest conducting mathematical dispersion modeling of emissions data to determine demonstration of compliance with ambient air target levels (OU 3);

4) suggest installing permanent soil gas monitoring wells on-site due to recent construction of commercial park buildings adjacent to the Site (OU 3);

5) the two ground water extraction systems and collection system are operating as designed (OU3 and 4), however, it is recommended that an evaluation of the performance of the extraction system be conducted, i.e., have the two contaminant plumes shifted or remain in the same locations. The reason for the need of this evaluation is that recent ground water data obtained from both on-and off-site monitoring wells indicate that all contaminant concentrations have decreased, some significantly. The aquifers affected by the contamination are no longer used as a drinking water source, with the exception of a few residences which are not near or expected to be near the plume limits and who's wells EPA periodically tests.

DEP is addressing all items associated with the cap. EPA is currently addressing the remaining items with support from the Corps of Engineers and EPA's RAC contractor.

EPA has reviewed the report and has determined that the remedial actions for Operable Units 1, 2, 3 and 4 are protective, therefore the remedy for the Site is protective of human health and the environment.

The next five year review will be conducted in September 2004.

STATEMENT OF PROTECTIVENESS

I certify that the remedies selected for this site remain protective of human health and the environment.

Patricia Meaney, Director
Office of Site Remediation And Restoration

3/22/2000
Date

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ACRONYMS AND ABBREVIATIONS

AAL	(Massachusetts) Ambient Air Level
ACL	Alternate Concentration Limit
AIC	Acceptable Intake - Chronic
AIS	Acceptable Intake - Subchronic
ARARs	Applicable or Relevant and Applicable Requirements
ARCS	Alternative Remedial Contracting Strategy
AWQC	Ambient Water Quality Criteria
CAA	Clear Air Act
CAG	Carcinogen Assessment Group
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGRL	Charles George Land Reclamation Trust Landfill
CMR	Code of Massachusetts Regulations
COC	Contaminant of Concern
cPAH	carcinogenic Polycyclic Aromatic Hydrocarbon
CWA	Clean Water Act
DEHP	Di(ethylhexyl)phthalate
EPA	Environmental Protection Agency
EO	Executive Order
ESAT	Environmental Services Assistant Team
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
HEA	Health Effects Assessment
HEAST	Health Effects Assessment Summary Tables
HMM	HMM Associates, Inc.
IRIS	Integrated Risk Information System
Kg	Kilogram
LDR	Land Disposal Restrictions
LRWU	Lowell Regional Water Utility
MADEP	Massachusetts Department of Environmental Protection
MANHESP	Massachusetts Natural Heritage and Endangered Species Program
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Limit Goals
MCP	Massachusetts Contingency Plan
MEK	Methyl Ethyl Ketone
MGL	Massachusetts General Laws
mg/L	Milligrams per Liter
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance

ORSG	(Massachusetts) Office of Research and Standards Guidelines
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCOR	Preliminary Close-Out Report
POTW	Publicly Owned Treatment Works
RAF	Relative Absorption Factor
RAC	Response Action Contract
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
TBC	To Be Considered
TCE	Trichloroethylene
TLV	Threshold Limit Value
µg/kg	Micrograms per Kilogram
USACE	Unites States Army Corps of Engineers
USDA/SCS	United States Department of Agriculture/Soil Conservation Service
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

1.0 BACKGROUND

This document provides a report on the modified Level Ia five-year review conducted by Metcalf & Eddy (M&E) for the Charles George Land Reclamation Trust Landfill Superfund Site (the Site) in Tyngsborough (*a.k.a.* Tyngsboro), Massachusetts for the U.S. Environmental Protection Agency (EPA) Region I. The purpose of the five-year review is to evaluate whether the response actions and original performance standards remain protective of human health and the environment. EPA is the lead agency and decision-maker for the Site. Metcalf & Eddy conducted the review and prepared the report in accordance with the Work Plan developed by M&E (1999) for Work Assignment No. 046-FRFE-0116 under EPA's Response Action Contract (RAC).

Pursuant to CERCLA Section 121(c), as amended, and Section 300.430(f)(4)(ii) of the National Contingency Plan (NCP), statutory five-year reviews are required at least every five years after the initiation of the first remedial action, for sites for which a post-SARA (SARA being the Superfund Amendments and Reauthorization Act) remedy (i.e., selected on or after October 17, 1986), upon attainment of the Record of Decision (ROD) cleanup levels, will not allow for unlimited use and unrestricted exposure. Policy five-year reviews are required (at least every five years after the initiation of the first remedial action) at sites for which a pre-SARA remedy (selected on or before October 17, 1986), upon attainment of the ROD cleanup levels, will not allow unlimited us and unrestricted exposure. Since the Operable Unit No. (OU) 1 ROD for this Site was signed in 1983, and because wastes remaining in the capped on-site landfill will not allow for unlimited use, future five-year reviews for this Site will also be policy reviews. EPA guidance stipulates that, for sites with multiple OUs, a single five-year review be conducted for the entire site, rather than conducting separate five-year reviews for each OU. A discussion of the progress of subsequent remedial actions or OUs should be included in future five-year reviews, as appropriate. The schedule for five-year reviews at this Site was triggered by the start of the remedial action at OU 1 in 1989. Therefore, the first five-year review was due in 1994, but was actually completed in 1995. This second five-year review, due five years after the date the original was due, was completed in March 2000. According to EPA guidance, the next five-year review is due within five years from when the previous review

was originally due, or by 2004. OSWER Directive 9355.7-02, Structure and Components of Five-Year Reviews (U.S. EPA, 1991 and 1994), sets forth the need for policy reviews, as well as the minimum requirements for statutory and policy five-year reviews.

In conducting this five-year review, M&E reviewed existing documents and other materials that are the basis for remediation of the Site, including documents that outline objectives, cleanup goals, and implementation of the remedial actions. The primary documents reviewed by M&E were:

- Record of Decision (ROD) I, December 29, 1983 (U.S. EPA, 1983)
- Record of Decision (ROD) II, July 11, 1985 (U.S. EPA, 1985)
- Record of Decision (ROD) III, September 29, 1988 (U.S. EPA, 1988)
- Five-Year Review, Final Report (M&E, 1995)
- Preliminary Close Out Report (PCOR) (U.S. EPA, 1998a)
- Lowell Regional Wastewater Utility (LRWU) Industrial Discharge Permit for the Site (LRWU, 1998)
- Off-site Sewer Extension as-builts and drawings
- Off-site Municipal Waterline Extension as-builts and drawings (Dufresne-Henry, 1998)
- Long-Term Groundwater Monitoring Report, Charles George Reclamation Trust Landfill, Tyngsboro, MA (TRC, 1996)
- Summary of Sediment Analytical Results for cPAHs, memorandum from E. Stanley to M. McDonough (U.S. EPA, 1998b)
- Summary of Enclosed Flare Operations, 12 Month O&M Period (April 1998 to April 1999)
- Emissions Testing of an Enclosed Flare (TRC, 1999b)
- Explanation of Significant Differences, September 29, 1999 (U.S. EPA, 1999c)
- Memorandum regarding On-Site Wetlands Evaluation/Mitigation (U.S. EPA, 2000)

In addition, the following monitoring data was available and reviewed:

- Draft Form I analytical data sheets for April 1999 groundwater sampling event
- Analytical data sheets for January 1999 surface water (and one wet well) sampling event
- Analytical data sheets for September 1998 sediment sampling event (metals and PAHs only)
- Analytical data sheets dated February 11, 1999 residential well monitoring
- Typical samples of O&M data reports for the enclosed flare and industrial discharge to LRWU

Currently, all Site remedies specified by three RODs have been implemented. This document is organized for a modified Level Ia review.

1.1 Site Description and History

The Charles George Land Reclamation Trust Landfill is a 60-acre mixed industrial, municipal, and hazardous waste landfill located approximately one mile southwest of the town center of Tyngsborough, Massachusetts (Figure 1-2). Land use in the vicinity of the site is predominantly rural residential but also includes some light industry and seasonal livestock grazing. This area of town has recently experienced heavy residential development. In addition, adjacent to the northern border of the site a large commercial park with a build-out capacity of 18 buildings is currently under construction. Drinking water in the area is supplied by local groundwater wells, by a new water main installed as a result of the EPA's first ROD for the site, and by recent water main extensions constructed by others. The public water supply is available to the area impacted by the Site, although some parties have chosen to remain with their private water supply wells. The water main is connected to the City of Lowell's system. The site is bordered to the east by U.S. Route 3, Flint Pond Marsh, and Flint Pond. Dunstable Road and Dunstable Brook border to the west, and the Cannongate Condominium complex is about 800 feet to the southeast. Blodgett Street forms the northwest border, eventually becoming Cummings Road.

The landfill itself contains municipal and industrial waste disposed on site from the mid-1950s until the landfill's closing in 1983. The landfill was permitted to accept hazardous industrial waste from 1973 until 1976.

1.2 Summary of ROD Remedies

The investigation and remediation of contamination at the Site are divided into three deliberations of remedial activities as follows:

- ROD I. Provide an alternative water supply (OU 1).
- ROD II. Control the contamination source (OU 2) to reduce off-site migration of contaminants (*i.e.*, cap the landfill and collect the leachate and landfill gas).

- ROD III. Provide treatment of groundwater, leachate and landfill gas and provide removal of Dunstable Brook sediments as the selected source removal remedy. ROD III covered both management of contaminated groundwater migration (OU 3) and leachate treatment (OU 4).

Selected remedial actions for the site were developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA), and to the extent practicable, the National Contingency Plan (NCP) at 40 CFR Part 300. Remedial alternative selection was documented in the RODs.

ROD I provided a permanent drinking water supply to local groundwater users by extending an existing water supply system (OU 1). In early studies, local groundwater wells were found to contain volatile organic compounds associated with the site. The remedy minimized exposure and, therefore, provided a measure of protectiveness to human health.

ROD II provided a cap for the site including a synthetic membrane and soil cover, a surface water management system, a passive landfill gas venting system, and a leachate collection system (OU 2). These measures minimized the migration of contaminants through the air and groundwater and, therefore, provided a measure of protectiveness to human health. The landfill cover minimized storm water infiltration which reduces leachate generation. From 1991 to 1997, leachate and groundwater were collected and pumped into a 3.5 million-gallon storage lagoon and at capacity, the wastewater was treated on-site in a temporary treatment facility. Treatment consisted of breakpoint chlorination, solids removal, and UV oxidation. The treated effluent was discharged to the eastern sedimentation pond with eventual discharge to Bridgemeadow Brook. Ambient Water Quality Criteria were met. Ten rounds of treatment were conducted, during which approximately 35 million gallons of wastewater were treated and discharged. The leachate collection system minimized impacts to off-site surface water and groundwater.

Construction of a synthetic landfill cap and appurtenant systems was begun in early 1989 and completed in October 1990. Included in the construction of the cap were a new shallow perimeter

leachate toe-drain, two leachate pump stations with force mains flowing to the temporary leachate holding pond, a passive gas collection and venting system, and a surface water diversion and sedimentation system. The old leachate collection systems on the east and west sides of the landfill, which were installed by the former landfill operator, were connected to the pump stations.

The landfill gas collection and venting system included a passive, crushed stone, gas collection trench system under the cap liner which directed the landfill gas through 28 vents along the top of the landfill. Three existing monitoring wells (acting as gas vents) were connected to an active horizontal header pipeline that lies atop the landfill. Twelve pre-existing vents were capped off. Landfill gas is being routed to an enclosedflare, part of ROD III. The landfill gas collection system delivers landfill gas to an interim flare. The flare, provided under ROD III, thermally destroys contaminants carried in the gas and minimized impacts to the air.

ROD III completes the remedial actions via treatment of the media controlled during implementation of ROD II. Due to several investigations made subsequent to the issuance of ROD III, EPA and the MADEP modified four of the five remedies under the third ROD. These changes included extending the existing municipal water supply system, installation of an enclosed flare, determination that removal of sediments from Dunstable Brook would not be necessary, and construction of a sanitary sewer extension, which provides an alternate remedy for leachate and groundwater treatment and discharge (U.S EPA, 1999c).

The southwest groundwater collection trench has been operating since October 1993, and the eastern groundwater extraction system has been operating since 1995. Contaminated groundwater from these two extraction systems is currently collected at the East and West Pump Stations, where citric acid and a biocide are added before the collected water is pumped to the leachate storage lagoon. From the lagoon, the water is pumped to the effluent monitoring station near the site entrance. From there, it is piped to the Cummings Road Pumping Station for discharge to the Lowell Regional Water Utility (LRWU) for treatment and disposal. This discharge is regulated by the LRWU Industrial Discharge Permit for the Site. The description of this system is included in Section 2.2.5. In the

future, flow will be pumped directly from the pump stations to the effluent station, bypassing the lagoon. The lagoon will then be decommissioned. The residential well monitoring program started in 1989 continues to date.

Landfill gas is currently being collected from an active gas extraction system of vents and header pipes via blower then treated via combustion in an enclosed flare.

The need for excavation of sediments from Dunstable Brook was re-evaluated as part of the first five-year review (M&E, 1995). Sediments that were to be dredged and placed under the landfill cap during cover construction remain in the brook. The decision to dredge the brook had been based on a risk assessment of contaminant levels using toxicity assumptions valid at the time ROD III was issued in 1988. In 1989, EPA revised the relative absorption factors for polycyclic aromatic hydrocarbons (PAHs), and in 1993, implemented the use of relative potency factors for carcinogenic PAHs (cPAHs). These changes were expected to result in decreased human health risk associated with exposure to sediments. Additional sediment data and a re-evaluation of relative absorption factors were presented in the first Five-Year Report (M&E, 1995). New risk calculations were not performed at that time, and EPA determined that more data was needed before dredging the brook. This report presents additional sediment sampling data and risk assessment information to support the decision not to dredge the brook.

The ROD called for on-site treatment with on-site discharge into the aquifer or off-site surface water discharge. During pre-design activities in preparation for concept design of the permanent treatment plant for OU 4, it was discovered that a sanitary sewer was constructed during the summer of 1996. EPA determined that the Site wastewater would meet the POTW's pretreatment requirements. Directing the discharge to the POTW is more cost effective, more environmentally protective and more reliable than the on-site treatment plant specified in the ROD (U.S EPA, 1999c).

1.3 Risk Summary

A risk assessment was performed for the site in 1988 (Ebasco, 1988). Human health risks were estimated to exceed the EPA target risk range from the following exposures:

1. Exposure to groundwater via ingestion during domestic use.
2. Exposure to airborne emissions from the venting system via inhalation of ambient air.
3. Exposure to sediments in Dunstable Brook via primarily dermal exposure to cPAHs.

In this five-year review, exposures to contaminants in groundwater and air are reassessed by the comparison of medium-specific concentrations detected during recent sampling to applicable or relevant and appropriate requirements (ARARs) including federal Maximum Contaminant Levels (MCLs) for groundwater and Massachusetts ambient air levels (AALs) for ambient air. In addition, contaminants detected in surface water have been evaluated through a comparison to human health ambient water quality criteria (AWQC). Oral risks from exposures to cPAHs in Dunstable Brook sediments were quantitatively reassessed by EPA (U. S. EPA, 1998a), using data from samples collected in 1998 and updated toxicity information. A supplemental recalculation of oral and dermal risk is included as part of this report. Summaries of the 1998 sediment data and risk recalculation are included below.

In August/September 1998, eight sediment samples were collected from upper Dunstable Brook and a tributary to it. In addition, one sample was collected from an upstream background location. All samples were analyzed for PAHs and metals. Table 1-1 presents a summary of the maximum and minimum detected levels and frequency of detection for the PAHs and metals listed in ROD III as sediment contaminants of concern as well as other detected compounds. Since toxicity information on the contaminants of concern have changed since 1988, Table 1-2 presents a summary of the changes for sediment contaminants of concern.

In reassessing the risk associated with exposure to Dunstable Brook sediments in 1998, only the ingestion route was included in the evaluation. In the 1988 risk assessment, the dermal route was assessed and the inhalation and ingestion routes were considered negligible. The 1998 reassessment

further assumed that receptors would be exposed to the maximum detected cPAH levels, and exposures would occur 350 days per year for 30 years. Using the toxicity values presented in Table 1-2, a cancer risk of 4.5×10^{-6} was estimated. This risk is within the EPA target cancer risk range of 10^{-4} to 10^{-6}. Arsenic, a sediment contaminant of concern listed in ROD III, was not included in EPA's qualitative reassessment (U. S. EPA, 1998a). Cadmium was not detected in 1998 sediments. Other metals and non-carcinogenic PAHs were detected but not included in the EPA's 1998 reassessment as there was no requirement to do so.

For this report, a recalculation of carcinogenic risk has been performed for all sediment COCs (arsenic and cPAHs) detected in Dunstable Brook sediments following current EPA Region I guidance. This recalculation includes the ingestion and dermal exposure routes. Dermal risks were estimated using the interim approach described in EPA's Dermal Guidance (U.S. EPA, 1992). Table 1-3 presents exposure information that has changed since 1988. The updated exposure assumptions have been used in the recalculation. Equations used to perform the risk calculations, as well as the results of the risk recalculation, are presented on Table 1-4. A total receptor cancer risk of 3.2×10^{-6} was estimated. This risk is within the EPA target cancer risk range of 10^{-4} to 10^{-6}. To conservatively evaluate the risk associated with other detected compounds in sediments (noncarcinogenic PAHs and metals), the maximum detected levels have been compared to EPA Region III Risk-Based Concentrations for Residential Soils, adjusted to a noncancer target risk level of 0.1 (Table 1-1). The lack of exceedances indicates that the presence of these additional compounds in sediment are unlikely to cause a risk to human receptors.

1.4 Remedial Action Objectives

Under its legal authorities, EPA's primary responsibility at Superfund sites is to undertake remedial actions that are protective of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences, including:

- a requirement that EPA's remedial action, when complete, must comply with all federal and more stringent state environmental standards, requirements, criteria or limitations, unless a waiver is invoked;
- a requirement that EPA select a remedial action that is cost-effective and that utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and
- a preference for remedies wherein treatment permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances.

CERCLA Section 121 also provides that if EPA selects a remedy not compliant with the above preferences, EPA is to publish an explanation as to why a remedial action involving such reduction was not selected. Response alternatives for the Charles George Land Reclamation Trust Landfill Superfund Site were developed to be consistent with these Congressional mandates.

EPA has established a three-tier approach to conducting five-year reviews. The most basic approach to five-year reviews provides a minimum protectiveness evaluation (Level I Review). Level II is the intermediate level of review, requiring new field sampling and a recalculation of risk. Level III is the highest level of a five-year evaluation of protectiveness. A Level III Review requires a new risk assessment. This report documents a modified Level Ia five-year review for the Charles George Land Reclamation Trust Landfill Superfund Site in Tyngsborough, Massachusetts, to confirm that the remedial action, as presented in the RODs, remains protective of human health and the environment.

This five-year review reassesses ARARs for substances identified as contaminants of concern and considers whether ARARs for substances not addressed under contaminants of concern have been changed such that the remedy is no longer protective. The review also considers pending or actual changes in zoning or land uses that could undermine the remedy. The review also considers the need for institutional controls at and near the Site. A five-year review has been performed for all OUs, using the information available, in accordance with EPA's five-year review guidance (U.S. EPA,

1994) and M&E's Work Plan (1999) for this assignment. The remedial action objectives, as described in the RODs, are as listed below.

1.4.1 Remedial Action Objectives: ROD I. The first ROD, issued in December 1983, established as an objective a new water main to provide an uncontaminated alternative water service to the residents of the Cannongate Condominium complex and surrounding area. The ROD specifically stated:

- Mitigate and minimize danger to and provide adequate protection of public health and welfare from ingestion of contaminated drinking water.

To meet this objective, the 1983 ROD selected the extension of an existing (Lowell's) water supply system to Cannongate Condominiums. Residential well water users along Dunstable Road up to Cannongate Road and along Cannongate Road were also tied into the waterline extension. An ESD was issued during the construction in 1988 to include these tie-ins, 24 in all. Contaminants of concern for the various media were not specifically named in the ROD.

1.4.2 Remedial Action Objectives: ROD II. The final remedial action objectives selected in the 1985 ROD for addressing source control measures at the Site are as follows:

- Abate additional impact to surrounding surface waters and wetlands.
- Minimize, to the extent possible, continued release to the groundwater.
- Control the emission of gases containing hazardous constituentsto the surrounding residents.
- Minimize potential contamination of the water supplies and impacts on recreational uses around Flint Pond.
- Minimize potential exposure, via direct contact with leachate, to the surrounding public and wildlife.
- Secure the Site to eliminate unauthorized access.
- Comply with existing federal, state, and local laws.

- Ensure a consistency with any off-site remedial alternatives which may be selected in the third ROD as required by CERCLA sec. 101(24).

1.4.3 Remedial Action Objectives: ROD III. The remedial action objectives selected in the 1988 ROD to address management of migration at the Site are as follows:

- Reduce potential future human health risks from ingesting benzene and arsenic in overburden groundwater southwest of the landfill.
- Reduce potential human health risks from benzene, arsenic, bis(2-ethylhexyl)phthalate, and trichloroethene in deep bedrock groundwater east of the landfill, with respect to use as a drinking water supply.
- Remediate shallow eastern groundwater to comply with Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) and Resource Conservation and Recovery Act (RCRA) groundwater corrective action requirements (40 CFR 264.92-100).
- Reduce potential human health risks posed by bromoform and various carcinogenic contaminants in landfill vent emissions (primarily, 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, vinyl chloride, methylene chloride, and carbon tetrachloride).
- Reduce potential human health risks from PAHs in sediments west of Dunstable Road in the leachate drainageway to Dunstable Brook, as well as short reaches of Dunstable Brook itself.

1.5 ARARS Review

An analysis of newly promulgated or modified requirements of federal and state environmental laws was conducted to determine which requirements are applicable or relevant and appropriate and to determine if they call into question the protectiveness of the remedy. The review accounted for updated regulatory standards promulgated since the RODs were issued. This report is based on review of the documents listed in the references section of this report.

Under Section III.A of Attachment I "Explanation of Five-Year Review Policy" to OSWER Directive 9355.7-02, the Commonwealth of Massachusetts should be requested to identify state ARARs promulgated or modified since ROD signature which may have a bearing on the protectiveness of the remedy. EPA is in contact with state officials regarding the Site.

1.5.1 Standards Review Approach. Chemical-specific ARARs, including criteria to be considered (TBC), used during development of the RODs were updated and changes were evaluated to determine the effects of the changes on the chosen remedial action and its effectiveness. The standards review was based on review of EPA-provided documents as well as published federal, state, and local rules and regulations.

An analysis of newly promulgated or modified requirements of state or federal environmental regulations was conducted to determine if these ARARs call into question the protectiveness of the remedy. Within this report, chemical-, location-, and action-specific requirements are tabulated. Changes to the requirements since the RODs were signed are highlighted.

The standards review also includes examination of analytical data collected from the Site, including post-closure monitoring data in comparison to federal and state standards. Recommendations are made as to whether any changes to the list of constituents of concern need to be made.

Many changes to the ARARs have occurred since the RODs were signed. These changes are presented in the subsequent subsections.

1.5.2 ARARs Review: ROD I. The basis for the 1983 ROD was developed prior to promulgation of the revised National Contingency Plan (40 CFR Part 300, March 1990) and prior to publication of the *CERCLA Compliance With Other Laws Manual: Parts I and II,* (OSWER Directives 9234.1-01 and 9234.1-02, respectively). The 1983 ROD set forth the Safe Drinking Water Act as an ARAR for the selected remedy.

1.5.3 ARARs Review: ROD II. The basis for the 1985 ROD was developed prior to promulgation of the revised National Contingency Plan (40 CFR Part 300, March 1990). The 1985 ROD set forth the following ARARs for the selected remedy:

- Resource Conservation and Recovery Act (RCRA), 40 CFR Part 264

- Executive Order 11988 (Floodplain Management)
- Executive Order 11990 (Protection of Wetlands)
- Clean Water Act
- Clean Air Act
- Safe Drinking Water Act

Since the 1985 ROD was completed prior to promulgation of the revised NCP and prior to publication of the *CERCLA Compliance With Other Laws Manual: Parts I and II*, (OSWER Directive 9234.1-01 and 9234.1-02, respectively), the ROD does not provide detailed analysis of the applicability or relevance and appropriateness of each regulation.

1.5.4 ARARs Review: ROD III. The 1988 ROD set forth the following ARARs for the selected remedy:

- Resource Conservation and Recovery Act (RCRA), 40 CFR Part 264
- Executive Order 11990 (Protection of Wetlands)
- Clean Water Act
- Clean Air Act
- Safe Drinking Water Act

ARAR tables presented in ROD III have been used as the basis of the ARAR review for this five-year review. Overall, many of the ARARs have changed since ROD completion in 1988. The tables listed below provide a review of the ARAR and a summary of newly promulgated or modified state and federal requirements.

Table 1-5. This table is a matrix of all contaminants of concern for all media, as identified in Table 6 of ROD III.

Table 1-6: Potential chemical-specific ARARs and guidance for the Charles George Land Reclamation Trust Landfill are evaluated in this table. The evaluation includes a determination of whether the rule is currently an ARAR or TBC and whether the remediation is in compliance with the ARAR.

Table 1-7: This numerical, chemical-specific ARARs table presents groundwater and leachate standards for all Site contaminants of concern listed in Table 1-5.

Table 1-8: This numerical, chemical-specific ARARs table presents surface water standards for all Site contaminants of concern listed in Table 1-5.

Table 1-9: This numerical, chemical-specific ARARs table presents ambient air guidelines for Site contaminants of concern.

Table 1-10: Potential location-specific ARARs and guidance identified in the RODs are presented.

Table 1-11: Potential action-specific ARARs and guidance identified in the RODs are re-evaluated. The re-evaluation includes a determination of whether the rule is currently an ARAR or TBC.

1.5.4.1 Chemical-Specific ARARs. Standards specified by the various chemical-specific ARARs have undergone significant revision since the three RODs were signed in 1983, 1985, and 1988. These revisions are reflected in the tables accompanying this text.

A requirement to be added to the chemical-specific ARAR list for the Site is the Massachusetts Surface Water Discharge Permit Program. Even though this program existed in 1988, the ROD did not identify its requirements as an ARAR. These regulations apply to any current or planned discharges to surface water bodies, such as Dunstable Brook, Bridge Meadow Brook, Flint Marsh, or Flint Pond. Although a Massachusetts surface water discharge permit is not required, equivalent documentation must be attained, and identified toxic pollutants are to be controlled to within equivalent effluent limitations. Discharge standards were established for the leachate and groundwater treated effluent. These standards were developed by the Massachusetts Department of Environmental Protection (MADEP) and have given EPA a window of five years to discharge, starting in 1992 and ending in 1996. Currently, no point-source surface water discharge or groundwater reinjection is occurring. All leachate and contaminated groundwater that is collected is discharged to the LRWU under permit No. 085. A biocide (to minimize iron bacterial growth) and citric acid (to keep iron dissolved) are added to the collected water prior to discharge to the

LRWU. These chemicals are added to minimize on-site iron fouling of pipes and appurtenances and are not necessary to comply with the LRWU industrial discharge permit. The state conducts periodic sampling of surface water runoff from the site and sediments in the sedimentation ponds as part of its O&M responsibilities under ROD II.

Although federal ambient water quality criteria are non-enforceable guidance developed under the Clean Water Act, and therefore cannot be applicable by definition, Section 121(d) of CERCLA specifies that these criteria be attained when relevant and appropriate. Environmental factors at the site render these requirements relevant and appropriate.

Criteria to-be-considered are also modified from the 1988 presentation. Massachusetts Drinking Water Health Advisories have been replaced by Massachusetts Office of Research and Standards Guidelines (ORSGs). Federal acceptable intake chronic and subchronic values are no longer used, having been replaced by Risk Reference Doses (RfDs). In addition, RfDs and Carcinogen Assessment Group (CAG) slope factors are two of several factors that may be used to calculate risk at a site. These criteria do not need to be identified in the ARAR section as they are usually covered under the risk assessment discussion. For the purposes of this re-evaluation, however, RfDs and CAG slope factors are updated on Table 1-2.

Revisions to the chemical-specific requirements affect treatment design, construction, operation, and maintenance as well as waste disposal practices. Environmental monitoring programs have been modified to address the chemical-specific ARARs, particularly the groundwater protection programs under RCRA and the Commonwealth of Massachusetts.

1.5.4.2 Location-Specific ARARs. The wetlands ARARs identified in the 1988 ROD still apply today to Flint Pond, Dunstable Brook, and to scattered wetlands which border the Site. The Resource Conservation and Recovery Act (RCRA) contains a number of explicit limitations on where on-site storage, treatment, or disposal of hazardous waste may occur. RCRA location

requirements and land disposal restrictions are considered to be location-specific ARARs. Other siting requirements are also considered an ARAR.

ROD II included a provision for the compensation of an anticipated loss of wetlands on the north side of the landfill with establishment of a larger wetlands to the south of the Site (ROD II, Consistency With Other Environmental Laws and Regulations Section). Wetland areas impacted by remedial actions were assessed in 1990. The Wetland Damage Assessment Report (HMM, 1990) stated that approximately 1.5 acres of wetlands were filled during capping activities and an additional 5 acres of wetlands were altered or otherwise damaged. This report also outlined general mitigation requirements and procedures. Based on a 1993 wetlands inspection, it appeared that the wetland mitigation proposed in the Wetland Damage Assessment Report had not been addressed since no replicated wetlands were observed and damage to other wetland areas persisted. As directed, no wetland assessment was performed for this five-year review. As the Site exists today, and as documented in the Administrative Record, there are no remaining wetlands onsite and wetlands replacement is not physically possible (U.S. EPA, 2000). As part of the cap remedy, three sedimentation basins were constructed to serve as surface water runoff discharge retention locations, and are considered to provide an environment similar to a wetland. These basins comprise 3 acres.

Although not related to ROD II, the Natural Resource Damages Trustees (NRDT) received settlement monies from the responsible parties for off-site injury to wetlands and groundwater resources. The damaged areas include Dunstable Brook, Flint Pond Marsh, Flint Pond and the Merrimack River. The monies will be used, in part, to recover these resources injured as a result of contamination from the Site. Included in the NRDT's plan are enhancing and expanding 18 acres of off-site property for wetlands (U.S. EPA, 2000).

Several requirements listed as location-specific in the 1988 ROD II have been deleted as being redundant with identified action-specific requirements.

1.5.4.3 Action-Specific ARARs. Action-specific requirements identified in the 1988 ROD were presented for all alternatives evaluated; action-specific requirements for the selected remedy were not clearly distinguished. An attempt has been made to clarify the requirements. The requirement status identified in Table 1-11 is accurate for on-going remedial actions.

Treatment of landfill gas is accomplished through an enclosed gas flare. The enclosed flare meets MADEP's requirements for BACT. Preliminary calculations show that, without any treatment, total VOCs emitted would be less than 0.368 ton per year, far less than the 1 ton per year level that triggers additional Massachusetts Division of Air Quality Control (DAQC) facility requirements. Since landfill gas emissions are being treated, total VOCs are further reduced and, thus, these rules are neither applicable nor relevant and appropriate.

2.0 CURRENT SITE CONDITIONS

This section summarizes the remedies performed and present conditions at the Charles George Land Reclamation Trust Landfill Site. In general, the groundwater remedy is ongoing, the source control remedy has been completed and leachate and sediments are being monitored. The remedy for replacement of the water supply has been completed beyond the original intended area.

The conditions described below are based primarily on information gathered during M&E's Site inspection. The site inspection was conducted on July 21, 1999 by three M&E Engineers (geotechnical, civil, chemical). Personnel from EPA Region I, the MADEP, and the U.S. Army Corps of Engineers (USACE) participated in the site inspection with the M&E personnel. The objective of the Site inspection was to observe current Site conditions and to identify areas or portions of the remedy that no longer comply with the required Site remedy as defined in the RODs. The Site inspection was limited to visual observations and interviews with EPA, MADEP, and USACE. A Site layout is provided as Figure 2-1.

Weather conditions during the inspection were hot and sunny and significant rainfall had not occurred in the month of July. A Site Inspection Checklist and Photograph Log were prepared and are included as Appendices A and B, respectively.

2.1 ROD I: Alternative Water Supply

A water line, providing an alternate water supply to serve the Cannongate area, was completed and activated in the fall of 1988. This waterline, which was constructed under ROD I and is OU 1, is now owned and operated by the Tyngsboro Water District (TWD). Since 1988, the municipal water line has been extended (not by EPA) along Westford Road to the Westec Industrial Park. Under ROD III, as a change in remedy from residential drinking water well monitoring (of most wells near the landfill), EPA extended the line from the Westec location on Westford Road to Middlesex Road, to the Academy of Notre Dame, then up Middlesex Road to Kendall Road and

finally to Flint and Upton Roads. This extension is part of OU 3 and will also be turned over to the TWD. The waterline in Dunstable Road was extended by others from the Cannongate Road/Dunstable Road EPA terminus, up Redgate Road, and also extended up Dunstable Road to Blogett/Cummings Road to the commercial park now under construction north of the site. The site is tied into this system. Figure 2-2 illustrates the extension of the area served by the municipal water supply system since OU 1.

2.2 RODs II and III: Source Control and Management of Migration

ROD II provided for source control by selecting a synthetic membrane cap with surface water diversion, off-gas collection and passive venting (now superseded by ROD III), and leachate seep collection. Construction of this cap and other remedial systems described above were completed in October of 1990. ROD III includes management of migration systems, control of groundwater, and leachate treatment. As RODs II and III both address appurtenances integral to landfill cap and closure, all these systems are discussed in this section. EPA and MADEP share responsibility for the O&M of these facilities. MADEP has O&M responsibilities of OU 2, which constitutes the cap, surface water diversion system, the leachate collection system and the grounds within the fence (including the fence). MADEP also has O&M responsibilities for the gas collection and the enclosed flare systems. MADEP fully funds these O&M responsibilities. Finally, MADEP has O&M responsibilities for the southwest groundwater extraction trench but provides for only 10% of the associated funding because any remedy for groundwater is funded by a EPA/MADEP 90%/10% respective split for the first ten years of operation. EPA currently maintains O&M responsibilities of the on-site leachate and groundwater collection and discharge systems (OU 4), excluding the southwest groundwater collection trench.

During the inspection in 1999, the landfill cover vegetation was typically one- to two-feet high on the cap and somewhat higher at the base of slopes to the west - in the vicinity of Blodgett Road and Dunstable Road. Overall, the landfill cap is in very good condition. Some minor maintenance issues are present as discussed below.

2.2.1 Landfill Cap and Features. The site inspection (site walkover) included overall reconnaissance from limited observation areas on the perimeter toe-of-slope, the cap access road, the crest of the landfill and the bench.

The landfill cap was inspected for HDPE geomembrane liner integrity as evidenced by surface cracks, erosion, settlement, vegetative growth, or poor drainage patterns. No areas of significant disturbance that would be expected to compromise geomembrane integrity were noted during the site inspection. Evidence of minor depressions collecting surface water were observed along the eastern landfill access road (Photograph 1-20). These localized depressions appear to be due to the construction methods used for the gas collection system. The gas pipelines appear to have been placed on the landfill surface and then covered in a mounded fashion. Minor differential settlement of these mounds and/or vehicular rutting of the driving surface appear to be the cause of these small drainage depressions. No damage to the liner appears to have resulted from these depressions but vigilance to this issue should be a priority for site maintenance activities.

Burrowing animals were not noted during the inspection although EPA/MADEP/USACE indicated that a family of red fox has been observed on the landfill. The presence of foxes may be limiting the presence of burrowing animal by predation.

2.2.2 Slope Stability. The Charles George Land Reclamation Trust Landfill is unusual in its construction due to the use of 2-inch ballast stone on many sideslopes in place of grass. Ballast stone constitutes approximately half of all the landfill surface area. There was no evidence of slope stability problems during the site inspection. The overall condition of the sideslopes was very good as illustrated by Photographs 1-2, 1-7, 1-23, 2-17, 2-18, and 2-21.

The Depression Area Repair that was completed after September 1994 above the Leachate Collection Pond appeared to be stable with no visible signs of differential settlement or movement.

No leachate breakouts were observed but EPA/MADEP/USACE indicated that there have been leachate breakouts off-site, beside the southbound lanes of Route 3, east of the landfill. This area was not observed by M&E during the Site inspection. MADEP has further noted that occasional breakouts are also apparent at the vicinity of the West Pump Station.

2.2.3 Vegetative Growth. Minor problems with respect to vegetative "bare" spots were observed in certain areas of the landfill, primarily along the cap access road to the east. These areas were sporadically covered with moss and other poorly-rooted plant species (Photographs 1-17 through 1-19).

Woody brush and sapling growth, however, is the biggest concern identified as a result of M&E's site inspection. Excessive plant growth was found on grassy portions of the landfill top (Photographs 2-3 and 2-7), along side slope areas (Photographs 2-11, 2-15 and 2-16) within rip rap-lined drainage channels (Photographs 1-3, 1-7, 1-15, 1-24, and 2-20), and sedimentation basins and, along the perimeter fence (Photographs 1-22, 2-24, and 2-25). The presence of woody brush and tree growth, if allowed to continue, could compromise the integrity of the geomembrane cap or the rip rap sideslopes of the sedimentation basins.

Discussion with EPA and MADEP indicated that control of woody plant growth had been established by means of mechanical mowing and hand cutting but that such efforts were proving to be expensive. Chemical control (e.g. herbicide applications) was being examined as a potential future approach. Currently, the landfill is mowed once per year with the last effort conducted during the fall of 1998.

2.2.4 Drainage Structures and Sedimentation Basins. All drainage areas appeared to be in functional order with the exception of the presence of excessive woody plant and shrub growth discussed in Section 2.2.3. Control of this growth will be a key emphasis for site maintenance activities to limit the potential for damage to the rip rap side slopes of the detention basins.

2.2.5 Leachate Collection, Groundwater Collection, and Treatment Systems. The leachate collection system, which consists of a drain that surrounds the landfill, was completed in October 1990. The southwest groundwater extraction trench was completed and became operational in December 1993. It includes five wells that vary in depth from about 24 to 45 feet. The eastern groundwater extraction well field was completed in July 1995.

The eastern groundwater extraction system originally consisted of four extraction wells: CDM-1, CDM-2, CDM-3, and PW-1A. CDM-1 and CDM-2 had low yields and low concentrations of contaminants. CDM-2, which was open to both the overburden and shallow bedrock, was taken off line in 1996; it was suspected that the groundwater in the shallow bedrock in that area was not contaminated. More recently, CDM-1 was also taken off line. A new extraction well, WES-1, was constructed near CDM-2. WES-1 is open to the overburden only and has a higher yield (11 to15 gpm) than CDM-2 (2 to 4 gpm).

The first five-year review (M&E, 1995) identified many problems with the leachate/groundwater collection systems. Among the problems encountered were:

- Pump failure due to iron bacteria build-up resulting in pump motor burnout.
- Lack of pump station access due to limited space and a hazardous atmosphere within the manhole caused by landfill gas (e.g., hydrogen sulfide) infiltration.
- Equipment corrosion also due to hydrogen sulfide infiltration.

These problems were addressed by redesigning the leachate and groundwatercollectionand pumping systems. The leachate collection and pumping systems appeared to be in appropriate working order based on the site inspection as well as a review of some of the O&M data.

Since January 1998, citric acid (continuous dosage resulting in 150 ppm concentration in the wastewater) and biocide (daily shock dosage) have been added to the collected leachate and groundwater to prevent iron biofouling of the discharge pipelines. Chemical addition occurs at

both the East and West Leachate Pump Stations, from which the water is pumped to the storage lagoon. From the lagoon, the water is pumped to the effluent monitoring station prior to discharge to the LRWU via the new Cummings Road Pump Station (located adjacent to the site, Photograph 2-23) and its associated combined force main/gravity sewer located on Dunstable Road. EPA extended the Westford Road sewer line to the Site. The extension includes two off-site pump stations, two force main sections, and the remaining sections are gravity forced. The EPA sewer line discharges to a pump station built by others located at the corner of Westford Road and Dunstable Road (*a.k.a.* Flint's Corner). Figure 2-2 also illustrates the extension of the wastewater connection.

Based on discussion with USACE, the groundwater/leachate collection system (combined discharge of the East and West Leachate Pump Stations) discharges approximately 9.2 million gallons per year to the LRWU. Average daily flow is approximately 34,000 gallons per 24-hour day based on five operating days per a seven-day week. The discharge is continuous during the workweek (*i.e.*, Monday through Friday) but the collection system is shut down on weekends at the request of LRWU. Inspections of the system are conducted every Monday and Friday during start-up and shutdown.

As described above, the extracted groundwater and collected leachate are currently discharged to the Leachate Storage Lagoon. However, the lagoon currently does not serve any permanent function for the leachate collection system, and it is the intent of the USACE to discontinue its use pending approval of a permit modification from the LRWU that was requested by EPA.

2.2.6 Landfill Gas Collection and Treatment System. A landfill gas collection and an interim open flare gas destruction system was constructed and became operational in 1994. During that year, landfill gas was characterized to determine the most appropriate destruction technology to meet the target cleanup levels established in ROD III. An enclosed flare system was determined to be the preferred alternative. Construction involved replacing the open flare stack with an enclosed flare stack. Some upgrading of the system was necessary, particularly the instrumentation and control

panels, but most of the original system was utilized, including the flare building. This construction was completed in April 1998.

Landfill gas is collected from the Charles George Land Reclamation Trust Landfill via a system of 29 gas extraction vents and three existing groundwater monitoring wells (acting as gas vents) connected to an active horizontal header pipeline that lies atop the landfill. The pipeline is connected to a vacuum blower and enclosed flare for thermal treatment (Photograph 1-14). There is no perimeter landfill gas collection system in place at the landfill.

The landfill gas vents are not extraction wells but are shallow structures that connect to the gas venting layer located directly beneath the HDPE geomembrane. Not all of the passive vents were connected to the header pipe system; those passive vents that were not connected to the gas extraction system were capped off and are no longer functional. In general, no landfill gas odors were present at the landfill except for two locations: a) area at the perimeter road near landfill gas vent #26, and 2) a few areas along the south slope where soil and vegetation were observed intruding onto the bench as illustrated on Photographs 2-15 through 2-18. Subsequent investigations have failed to indicate a release of landfill gas from the area of the south slope bench. Periodic, future review of this area is expected to continue as part of normal maintenance and operations.

Discussion with EPA/MADEP/USACE indicated that air intrusion with the current gas extraction system is the primary limiting mechanism on operation of the landfill gas collection system. When excessive oxygen occurs in the extracted landfill gas, the system is shut down until re-equilibration occurs. This appears to be the most common reason for unplanned shutdown of the enclosed flare system. Other than the "high oxygen" alarm shutdowns, the flare system appears to be operating in acceptable fashion. Review of recent O&M data shows that landfill gas flow rates are in the range of 150 to 170 standard cubic feet per minute with flare temperatures operating @ 1,600±100° F. Three leachate toe-drain cleanouts were connected to the gas collection system and utilized until approximately one year ago. These cleanouts have been closed due to the oxygen infiltration

problem. With the exception of the air intrusion problem, the landfill gas collection system appears to operate in an adequate manner.

2.2.7 Monitoring Systems. A groundwater monitoring well network exists at the landfill but was not observed during the site inspection. Semiannual inspection and monitoring of this network has been performed by TRC Environmental Corporation since April 1999 under the RAC Program. The monitoring includes water level measurements in all wells and sampling of 12 key wells (with one "floating" well).

Monitoring was previously done by TRC from October 1992 through July 1996 under the ARCS Program. Water levels were monitored on a quarterly basis during this period, and groundwater samples were collected from select monitoring wells semiannually in November and April. Based on the monitoring during that period, TRC concluded that the eastern and southwestern plumes were persisting. TRC surmised that the limited period of operation of the eastern groundwater extraction system and the operational deficiencies of the western collection trench contributed to the continued presence of the plumes.

More recently, under the RAC Program, groundwater samples were collected from selected monitoring wells in April 1999. Samples from wells in the overburden and shallow bedrock near the southwestern and eastern extraction systems indicated the presence of VOC contamination. Since the monitoring wells are close to the extraction systems (particularly on the east side of the landfill), it was not possible to determine if the contaminated groundwater is within or beyond the capture zones of the systems.

Monitoring of collected leachate/groundwater occurs at the effluent monitoring station located behind the Operations Building (Photograph 1-1). This station receives the discharge from the leachate storage lagoon (to which both the East and West Leachate Pump stations discharge) prior to discharging to the LRWU. By permit with LRWU, continuous monitoring of pH, temperature

and flow rate (gallons per minute) occurs at the station along with collection of composite samples (via a refrigerated "ISCO" sampling unit) and grab samples.

Monitoring of landfill gas occurs at both the individual gas vents on top of the landfill as well as the flare/blower station. Sample taps are in place at each gas vent for collection of samples using hand-held instruments. Each vent also includes a pressure gauge to measure small changes in static pressure (either positive or negative) to allow adjustment to extraction rates from each vent but these were generally not operational and have not been found to be useful for this site. Automated monitoring at the flare/blower station involves the following parameters: flare temperature, landfill gas flow rate, vacuum pressure of the extracted landfill gas and oxygen concentration of the extracted gas. Based on review of the O&M data, the oxygen sensor is a high maintenance item that frequently requires replacement of oxygen analyzer units.

Although there are no permanent perimeter monitoring wells for measuring methane or landfill gas in the vadose zone, the MADEP has monitored the soil gas using multiple, temporary, surficial probes. These probes were monitored once in 1998, during the summer of 1999, and plans are in place to conduct another round of monitoring soon. Further, MADEP is implementing a quarterly monitoring program through it's contractor. Twenty probes will be included in the program. These temporary probes were installed as part of prior landfill gas migration studies (M&E, 1997). In general, gas migration has not been an issue at the site in the past due to the lack of sensitive receptors such as nearby structures or buildings. Recent construction along the landfill's northern boundary, however, was observed during the site inspection and discussion with EPA indicated that an industrial park development was under construction adjacent to the landfill.

2.2.8 Access Roads. The condition of access roads along the landfill perimeter as well as the top of the landfill appeared to be satisfactory during the site inspection. Some areas of excess vegetation were observed as outlined above.

2.2.9 Site Security. Site security appears to be functioning according to the prescribed remedy. The perimeter fence, which is 6-foot- high chain-link type with triple strands of barbed wire, appears in undisturbed condition. Warning signs were placed approximately with 50-foot spacing. No evidence of vandalism was apparent during the inspection. At least one warning sign at the Leachate Collection Pond was damaged.

2.2.10 Miscellaneous Site Features. M&E was not able to locate the two survey monuments listed on the "as-built" drawings for the landfill (Sheet C-2, Existing Conditions, dated 1/15/92). These monuments were formerly located along Blodgett Street approximately 650 feet north of the main entrance gate to the site and at the junction of Blodgett Street and Dunstable Road. Based on discussion with EPA and MADEP, the Blodgett Street monument that is north of the main entrance gate may have been damaged or destroyed as a result of installation of the new waterline and wastewater sewer connections to LRWU during site-related activities or by others. Neither EPA or MADEP have any information about the monument at the junction of Blodgett Street and Dunstable Roads.

3.0 COMPLIANCE STATUS

The Site is being remediated and monitored under the guidance of three RODs.

3.1 Compliance with ROD I: Alternate Water Supply

Remedial action objectives for the first ROD (U.S. EPA, 1983) stipulated mitigating and minimizing danger to and providing adequate protection of public health and welfare from ingestion of contaminated drinking water. ROD I provided for a permanent drinking water supply to local groundwater users by extending an existing water supply system. As-built drawings (Hoyle, Tanner & Associates, 1991) indicate that a permanent water line was installed to supply water from the City of Lowell to residents of Dunstable Road, Cannongate Road, Turnbuckle Lane, and Axletree Road.

Originally, the ROD only included the Cannongate Condominiums to be serviced by the water line. However, on-going residential well monitoring by the State of Massachusetts and the EPA indicated the sporadic presence of antimony and lead above their MCLs, neither of which was included as a compound of concern in ROD I. This led to the addition of 24 residential services along Dunstable Road and is documented in an ESD (U.S. EPA, 1988c). The municipal water line has since been extended along Westford Road, Middlesex Road (Route 3A), and to Winslow Drive, Flint Road, Upton Drive and Notre Dame Academy.

The alternative water supply meets the remedial action objective and conditions of ROD I, and is in compliance with state and federal drinking water requirements.

3.2 Compliance with ROD II: Source Control

The remedial alternatives selected under ROD II were selected to control the source of contaminants from the Site. The following control systems were implemented to achieve the remedial action objectives listed in Section 1.4.2 of this report:

- Landfill cap with 3:1 side slopes, a surface water collection and diversion system, and a passive landfill gas collection and venting system.
- Full peripheral leachate collection system including pump stations, leachate holding pond and intermittent treatment.
- Annual mowing and maintenance of the vegetated surface.
- Quarterly inspection of the pump station, leachate collection/disposal system, and cap surface.

These actions, while not completely mitigating the migration of contaminants, achieved the objective of controlling the migration of contaminants by minimizing storm water percolation through the landfill, minimizing landfill gas venting by restricting the available area of venting, and controlling the offsite migration of contaminants in leachate via collection, holding and periodic treatment. In this way additional impacts to surrounding surface waters and wetlands were abated and continued releases to groundwater minimized. Fencing was installed to eliminate unauthorized access to the Site. ROD II provided for further remedial action if necessary through "an additional feasibility study to evaluate the groundwater and off-site remediation, whether the treatment of vent gases is required, and the effectiveness of the leachate handling option selected." (U.S. EPA, 1985)

3.2.1 Landfill Cap, Surface Water Collection and Diversion System, and Passive Landfill Gas Collection and Venting System. The construction of the landfill cap and appurtenant systems was completed in October 1990. During the cap inspection conducted as part of this second five-year review, the cap integrity was observed to be in good condition with minor maintenance issues, as discussed in Section 2.0 of this report. These maintenance activities are listed in the

recommendations section of this five-year report. Based on the Site inspection and review of documents, the landfill cap is in compliance with the requirements of ROD II and ARARs.

The surface water diversion and collection system was observed to be functional during the cap inspection. The diversion swales and detention basins appeared to be performing as designed and in good condition (see photo log). There was a lack of rutting and erosion on slopes and of other indications of secondary diversion of surface water (such as ponds, vernal pools, dry channels, etc.) that support the observed functionality of the surface water diversion and collection system. Evidence points to continued functionality of the surface water system and compliance with ROD II.

Site security was observed to be maintained via a continuous fence surrounding the site, security gates to control site access, and, at the time, personnel tracking upon entrance. Site security is in compliance with the requirements of ROD II and ARARs.

The passive landfill gas venting system is no longer evident at the site. It has been upgraded under the remedial alternative selected in ROD III.

3.2.2 Full Peripheral Leachate Collection System. Since the completion of the cap in 1990, leachate generation has been reduced. Leachate that is currently collected by the peripheral drain is combined with extracted groundwater at the East and West Pumping Stations. The combined liquids are then pumped sequentially to the storage lagoon, to the effluent monitoring station, to the Cummings Road Pumping Station, and to the LRWU. The leachate collection and treatment systems were observed to be in working order, as discussed in Section 2.0 of this report. The current leachate collection and management system is in compliance with the requirements of ROD II.

After completion of the leachate collection system in October 1990 and prior to installation of the sewer discharge to LRWU, leachate and groundwater were routed to the 3.5 million-gallon storage lagoon and treated on a batch basis with a portable, skid-mounted system located next to the lagoon. This system included solids removal via a clarifier and UV/chemical oxidation with discharge to

surface water. Ten rounds of treatment took place between 1991 and 1997, treating approximately 35 million gallons of collected leachate and groundwater.

3.2.3 Annual Mowing and Maintenance of the Vegetated Surface. The cap is mowed annually in compliance with ROD II, but the annual mowing has not been effective in controlling the growth of woody brush and saplings. More frequent mowings may be desirable. In addition, there are a few, small bare spots on the slope of the landfill. These issues are being addressed under current maintenance.

3.2.4 Quarterly Inspections. Based on discussion with EPA, MADEP and USACE, operation and maintenance activities for the Charles George Land Reclamation Trust Landfill are conducted frequently and rigorously. Weekly inspections are conducted of the pump station, leachate collection/disposal system, landfill gas treatment and collection system and the landfill cap.

3.2.5 Compliance with Existing Federal, State, and Local Laws. Based on inspection of the Site, review of Site documents, and discussions with the EPA, MADEP and USACE, remediation activities are generally in compliance with existing federal, state and local laws. While not a compliance issue, it may be desirable to update the Post-Closure O&M Plan to current requirements.

3.3 Compliance with ROD III: Management of Migration, Groundwater Collection, and Leachate Treatment

The objective of remedial alternatives selected in ROD III (U.S. EPA, 1988a) selected to perform on-site remediation of groundwater, leachate, and landfill gas; perform off-site source removal of contaminated Dunstable Brook sediments; and perform long-term monitoring of the bedrock groundwater aquifer and off-site residential wells. This objective was achieved by the implementation of the following remedy components:

- Construction of a southwest groundwater extraction trench and an eastern groundwater extraction well field;

- Construction of a landfill gas collection system and thermal destruction of landfill gas emissions;
- Removal of approximately 500 cubic yards of sediments in Dunstable Brook;
- Residential drinking water well monitoring; and
- Groundwater collection and leachate treatment.

3.3.1 Construction of a Southwest Groundwater Extraction Trench and Eastern Groundwater Extraction Well Field. The selected remedy for groundwater and leachate in ROD III includes a groundwater collection trench in the overburden along the southwestern side of the landfill, a groundwater collection system in the overburden and shallow bedrock on the eastern side of the landfill, and a groundwater diversion trench upgradient (north) of the landfill. The peripheral leachate collection system, discussed in Section 3.2 above, was part of ROD II.

3.3.2 Construction of a Landfill Gas Collection System and Thermal Destruction of Landfill Gas Emissions. Parts X.B and XI.B of ROD III required the following aspects as part of the landfill gas collection and thermal destruction remedy:

- Collect gas from the landfill vents into a single collection system.
- Combust the gas in a fume incinerator; sustain combustion temperatures of 1,200°F or higher using methane contained in the landfill gas.
- Operate in "induced draft" or vacuum mode to minimize fugitive emission leaks to ambient air.
- Provide for gas sampling throughout the system as well as the stack.
- Continuously monitor combustion parameters of temperature, carbon monoxide (CO), carbon dioxide (CO_2), oxygen (O_2) and total hydrocarbons to provide indication of the destruction removal efficiency.
- Conduct periodic monitoring of the volatile organic compounds-of-concern to confirm compliance with EPA's on-site, risk-based target cleanup levels.
- Conduct on-site air monitoring downwind of the stack to confirm compliance with national secondary ambient air quality standards (NAAQS) and state AALs.

- Install additional secondary treatment device if in non-compliance with the NAAQS or AALs.
- Achieve appropriate cleanup levels at a representative location in the thermal destruction system stack; conduct four consecutive sampling episodes during flare startup. Analyze VOC emissions annually to determine compliance with target cleanup levels.

The Charles George landfill flare and blower currently collect and treat gas from a single system of extraction vents and header pipelines located within the landfill. This system is operated in an induced draft or vacuum mode to minimize fugitive emissions. Landfill gas quality is currently being monitored under capped conditions and can be measured at each individual well location as well as at the flare system inlet. Monitoring of the stack exhaust from the enclosed flare can be measured via means of sample ports located at the top of the stack enclosure.

The selected remedy allowed for design and installation of the landfill gas collection system concurrent with the landfill cap installation. This system and an interim, open candle-type flare were designed (Law, 1991) and built. The "interim" flare (candle-type flare) is no longer operational and has been removed from the site. The interim flare has been replaced by a permanent installation which consists of an enclosed landfill gas flare for gas destruction. The enclosed flare operates at a typical temperature of 1,600°F. The interim flare, followed by construction of a permanent, enclosed flare, were deviations from the fume incinerator called for in ROD III to combust the landfill gas. These differences were noted in EPA's PCOR (U.S. EPA, 1998a). Use of an enclosed flare for thermal combustion of landfill gas is an accepted industry practice and, in M&E's opinion, provides comparable performance to a fume incinerator.

Landfill gas quality is being monitored under capped conditions. Parameters monitored in the inlet gas to the enclosed flare include the following: a) landfill gas flow rate, b) flare operating temperature and set point, c) vacuum pressure of collected gas, d) oxygen concentration of the collected gas and e) date & time of readings. These parameters are currently monitored by installed instrumentation on the flare system on a continuous basis. While these are slightly different from

those proposed in ROD III, they are appropriate, when combined with flare stack testing results, for determining combustion performance of an enclosed flare.

ROD III includes the requirement for periodic testing to confirm compliance of the enclosed flare emissions with the EPA's site-specific, risk-based target cleanup levels. Stack testing was conducted by TRC during February 1999 (TRC, 1999b). A comparison of these stack testing results versus the ROD III target cleanup levels for a select group of volatile organic compounds are shown in Table 3-1. The emissions from the stack met all of the target cleanup levels presented in ROD III.

ROD III includes annual on-site ambient air monitoring to assess compliance with federal NAAQS and Massachusetts AALs. This monitoring and compliance with these standards have not been demonstrated at this time.

3.3.3 Removal of Approximately 500 Cubic Yards of Sediments in Dunstable Brook. The selected remedy for sediments given in ROD III is dredging of the unnamed stream leading from the west leachate pump station area to Dunstable Brook and possibly some downstream reaches of the brook. Dredging was to occur to a depth of approximately one foot below grade, with sediments to be placed on the landfill below the cap. Before dredging had been accomplished, EPA revised the relative absorption factors for cPAHs and implemented the use of relative potency factors for cPAHs. The use of these revisions would result in a decreased risk associated with exposure to cPAHs in sediments. Risk from exposure to Dunstable Brook sediments was re-evaluated in 1998 after sampling was conducted. This re-evaluation indicated that the cPAH levels in Dunstable Brook have decreased and ingestion risks are within the EPA target cancer risk range. Based on the 1998 risk calculations, EPA decided not to dredge the brook. A risk recalculation performed as part of this report, including the oral and dermal exposure routes, confirms that current cancer risk estimates are within the EPA target risk range. Therefore, it is unlikely that residual contaminants in sediment present a risk to human receptors. These changes to the ROD remedy are documented in the ESD for the Site EPA, (1999c).

3.3.4 Residential Drinking Water Well Monitoring. In October 1995, routine groundwater samples taken from monitoring wells on the Notre Dame Academy property within 600 feet of the water supply well revealed the presence of organic contaminants that were believed to have come from the landfill. The concentration of several contaminants were above federal and state drinking water standards, or in excess of state drinking water guidelines. To ensure a safe drinking water supply, EPA provided funding through an advance Cooperative Agreement with MADEP for the construction of an extension of the existing municipal water system to the Academy. MADEP entered into an agreement with the Tyngsborough Water District, whose contractors performed the construction. This water line extension was completed in July 1997.

In August of 1996, a landfill contaminant with a concentration above the state drinking water guideline was discovered in a residential drinking water well in the Flint Pond neighborhood. EPA funded further extension of the water line to this neighborhood through an amendment to the MADEP Cooperative Agreement described above. This extension was completed in June 1998. Residential well monitoring now only includes a few homes south of the landfill.

3.3.5 Groundwater Collection and Leachate Treatment. Contaminated groundwater from the two extraction systems and leachate from the peripheral drain are currently collected at the East and West Pump Stations. Citric acid and a biocide are added to the combined flows before they are pumped to the leachate collection pond. From the pond, the water is pumped to the effluent monitoring station, after which it is piped to the Cummings Road Pumping Station for discharge to the LRWU for ultimate disposal. This discharge is regulated by the LRWU Industrial Discharge Permit for the Site.

Under the OSWER guidance on five-year reviews, groundwater and leachate remedial action is considered a Long-Term Remedial Action (LTRA). Compliance with ARAR's is not necessary at each five-year review because attainment of ARARs is expected to require up to 30 years. The guidance does specify updating of ARARs. Groundwater and leachate target cleanup goals given in Table 8 of ROD III have been updated and provided in Tables 1-8 and 3-2.

4.0 STATEMENT ON PROTECTIVENESS

4.1 Statement on Protectiveness for ROD I

Based on the data base evaluation, protectiveness has been demonstrated for the ROD I (1988) compounds of concern. A statistical analysis of the database in accordance with 40 CFR 264.90-264.109 should be performed on the results to confirm the presence or non-presence of other contaminants at significant levels. This analysis is outside the scope of this five-year review.

4.2 Statement on Protectiveness for ROD II

Based on M&E's field inspection, the landfill cap appears to be in good condition, and its integrity is being maintained by O&M efforts. Additional maintenance effort, however, is needed to prevent the formation of woody plant growth which can ultimately damage liner integrity. The presence of the woody plant growth was noted during M&E's inspection.

Based on M&E's field inspection, the landfill gas collection and treatment system appears to be in good working order and is being inspected , maintained and serviced on a regular basis.

In discussion with USACE and MADEP, it was determined, however, that the landfill gas (LFG) collection system is very sensitive to "overpulling" if the landfill gas blower is operated at too high a vacuum pressure. "Overpulling" the gas collection system causes air to be drawn into the collected landfill gas. The presence of too much air requires that the system be shut down to avoid the formation of a combustible mixture of methane (from the landfill gas) and oxygen (from air). This causes periodic shutdowns of the system. Therefore, the gas collection system requires steady vigilance as part of routine O&M. The sensitivity of the gas collection system is due to the original construction of the landfill for passive venting of landfill gas. A gas venting layer was originally constructed just below the geomembrane cap. The gas venting layer serves as a pathway for air intrusion into the landfill gas. In addition, the gas vents which connect to the header pipelines only

extend to the shallow depths of the gas vent layer. Modifications would be required if the efficiency of the landfill gas collection system had to be improved. These modifications would likely include re-drilling of landfill gas wells to greater depths and elimination or mitigation of the existing gas vent layer located below the geomembrane.

The leachate collection system is operational and appears to be in good working order. Assuming that the cap is effectively preventing infiltration into the landfill, leachate production and migration in the unsaturated zone should be minimal. The leachate collection system should therefore only collect fluid if it periodically or permanently lies below the water table or a perched water table. No leachate outbreaks were noted during the M&E inspection. It is not clear, however, if the system is adequate to prevent further leachate outbreaks. Off-site outbreaks have occurred in the past in the area of the side slope leading from the east edge of the landfill to the southbound lanes of Route 3; however, it is not known if the outbreaks were leachate or leachate-contaminated groundwater.

4.3 Statement on Protectiveness for ROD III

The sediment remedial action has not been implemented. However, protectiveness for exposure to cPAHs and arsenic has been demonstrated via the 1998 sediment analysis, the recalculation of sediment cancer risk for cPAHs performed in 1998 (U.S. EPA, 1998b), and the recalculation of oral and dermal cancer risks for cPAHs and arsenic as part of this report. A qualitative evaluation of other detected compounds from Dunstable Brook sediments (noncarcinogenic metals and PAHs) indicates that these compounds are present at levels that are unlikely to present a noncancer risk to human health. However, cumulative noncancer risk has not been calculated. Ecological criteria and toxicity testing conducted in 1995 (M&E, 1995) indicated the sediment in Dunstable Brook was toxic to ecological receptors.

The groundwater collection systems have been built and are operational. However, problems related to groundwater quality have in the past caused operational deficiencies at the groundwater extraction systems, specifically the iron fouling of on-site pipes and appurtenances. These operational

difficulties, resolved by the addition of chemicals to the collected water prior to discharge to the off-site treatment plant, did not call into question the protectiveness of the remedy. Only one round of groundwater monitoring has been conducted since 1996, and contaminants were detected in some of the wells at that time (April 1999). Whether this contamination indicates that the groundwater extraction systems are not completely containing the plumes cannot be determined from the existing information.

The landfill gas collection and thermal combustion systems have been constructed, are operational and well maintained and based on the recent flare stack testing conducted during February 1999 are meeting the target cleanup levels set forth in ROD III.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This section summarizes the findings and discusses the conclusions that have resulted from the second five-year review for the Site.

5.1.1 Landfill Cap and Appurtenances and Leachate Collection. Based on M&E's field inspection, the landfill cap appears to be in good condition and its integrity is being maintained by vigilant O&M efforts. Additional maintenance effort, however, is needed to prevent the formation of woody plant growth which can ultimately damage liner integrity. The presence of the woody plant growth was noted during M&E's inspection.

The leachate collection system was observed to be operational and meeting its intended collection function. It is not clear, however, given the construction of the landfill, that the system is either adequate or could be adequate to prevent off-site leachate outbreaks from the landfill or leachate impacts to groundwater.

5.1.2 Gas Collection and Treatment. Based on M&E's field inspection, the landfill gas collection and treatment system appears to be in good working order and is being inspected, maintained and serviced on a regular basis. Based on the stack testing conducted-to-date, emissions from the enclosed flare are within target cleanup levels set forth in ROD III. No landfill gas odors were detected during the inspection. There was no evidence of LFG fugitive emissions or offsite migration of landfill gas based on M&E's limited inspection and review of the documents-to-date. In the event that either of these issues become problems in the future, the current collection system would be limited in mitigating these without extensive reconstruction and modification to eliminate the air intrusion sensitivity.

ROD III does contain a requirement for on-site ambient air monitoring of the final landfill gas treatment system. There is currently no on-site ambient air data available to demonstrate compliance with ambient air standards. The intent of this monitoring was to demonstrate compliance with the federal NAAQS and Massachusetts AALs. It is generally accepted practice that compliance with these requirements is determined by means of mathematical dispersion modeling using the results of point source emissions such as the enclosed flare. It is recommended that, in lieu of collecting ambient air sampling data, mathematical modeling be conducted using the results of the flare stack testing to demonstrate compliance with these standards.

5.1.3 Groundwater Collection and Treatment. A leachate and groundwater collection system is in place at the Site. Water collected is pretreated and discharged to the LRWU under Permit No. 085, at an average daily flow rate of 34,000 gallons per day, continuous Monday through Friday.

The groundwater collection systems on the east side of the landfill have over the years experienced some operational difficulties, primarily with biofouling of the eastern lines. Problems encountered have been solved by chemical addition to prevent biofouling (Durgin *et al*, 1996). Remaining problems are handled under routine operation and maintenance. Both collection systems were operational at the time of the inspection, although one extraction well in the eastern system was inactive. A set of groundwater samples that was collected from some of the monitoring wells around the landfill indicated the continued presence of contaminants. Whether the contamination was beyond or within the capture zones of the collection systems could not be determined from the available data. In any event, since 1) the monitoring data indicate that the plumes are still present and 2) the configuration of the eastern extraction system has changed (one less well) compared to the original construction, it might be prudent to reevaluate both extraction system capture zones to confirm that they are protective.

5.1.4 Wetlands and Drainageways. Based on the re-evaluation of sediment risk performed in 1998 and as part of this report, it is unlikely that residual contaminants in sediment presents a risk to

human receptors. The human health re-evaluation supports the decision to leave Dunstable Brook sediments in place.

5.2 Recommendations

Based on completion of the site inspection and review of related documents, M&E has developed the following list of recommended actions for continued operation and maintenance of the Charles George Land Reclamation Trust Landfill Site and associated features:

- Expand the semi-annual groundwater monitoring program to demonstrate compliance with the RAOs of ROD III. Select wells for the program that are located both upgradient and downgradient of the groundwater extraction systems in the strata of concern to evaluate the performance of the systems and to verify compliance with the ROD. This program could also be implemented with the quarterly landfill gas monitoring. (It should be noted that long-term groundwater monitoring was re-established in April 1999. The recommendation is that this monitoring continue and not be allowed to lapse.)

- Investigate the causes of landfill bare spots and provide appropriate vegetative cover by means of soil testing for appropriate analytical parameters, provide appropriate vegetative support soil by means of fertilizer applications, addition of organic content and reseeding. This work should be performed with appropriate input from a soil scientist or agronomist.

- Monitor low-spot areas on the top of the landfill during or immediately after rain events to check if water is ponding. If necessary, conduct remedial activities to eliminate those areas where extensive ponding occurs.

- Eliminate all woody shrub and tree plant growth within areas of the HDPE geomembrane capped portion of the site to prevent damage to the liner. In areas with extensive woody growth, inspect and repair the liner as necessary after removal of the growth.

- Eliminate, control, or minimize woody plant growth within sedimentation basins as well as along the perimeter security fence to avoid long-term damage to these structures.

- Install permanent vadose zone, gas monitoring wells along the landfill's northern boundary where off-site development and construction is planned. Conduct testing for explosive gases (e.g. methane) to confirm compliance with the landfill gas migration ARAR at the site property boundary. Consider including the as part of the soil gas monitoring and evaluation program: 1) compilation and review of past soil gas data from the temporary probes to aid in placement of permanent probes, 2) incorporation of the three permanent soil gas probes installed on the Cannongate Condominium complex property and 3) placement of new, permanent soil gas probes to monitor on-site structures not constructed for explosion-proof conditions such as the O&M Building, Flare Blower Building, East Pump Station Building, West Pump Station Building, Lagoon Pump House and the Cummings Road Pump Station.

- Re-establish appropriate benchmarks at the Site boundary to replace those that have been damaged or destroyed. Temporary benchmarks could be located on new fire hydrants which have been installed along Blodgett Street.

- In the event that off-site landfill gas migration or off-site landfill odors become a concern, conduct appropriate field testing, design assessments and remedial actions to improve the efficiency of the landfill gas collection system.

- Continue to conduct either an aerial or ground survey of the landfill to evaluate conditions for future five-year inspections.

- Obtain sufficiently low detection limits during future enclosed flare stack testing events to demonstrate compliance with the ROD III target cleanup level for 1,1-dichloroethene.

- Conduct mathematical modeling using the flare stack testing conducted-to-date to demonstrate compliance with the federal NAAQS and Massachusetts AALs.

5.3 Next Review

Five-year reviews are done every five years at sites where contaminant levels remain at concentrations that prevent unlimited, unrestricted use of the Site. Since remedial actions have not been completed for all OUs, a third five-year review will be required. In addition, if the completed remedy does not allow for unlimited, unrestricted use of the Site due to residual contamination, future reviews may be required. Five-year reviews are triggered by the date remedial actions are initiated at any OU. When a five-year review is conducted at a time other than when it is due, the next five-year review is due within five years of the time when it was originally required (U.S. EPA, 1994). Each five-year review is to cover all OUs at a site, whether or not remediation at that unit is complete (U.S. EPA, 1994). The next five-year review for the Charles George Land Reclamation Trust Landfill Superfund Site should be conducted in 2004.

6.0 REFERENCES

Camp, Dresser, and McKee, Inc. (CDM), 1986. *Operations and Maintenance Plan for Post Closure Period, Charles George Landfill Site, Tyngsborough, Massachusetts.* Prepared by Camp Dresser McKee, Inc. (CDM) for the U. S. Environmental Protection Agency, December 1986.

Camp, Dresser, and McKee, Inc. (CDM), 1992. *Technical Evaluation of Leachate Pump Facilities, Charles George Landfill, Tyngsborough, Massachusetts.* Prepared by Camp Dresser McKee, Inc. (CDM) for the U. S. Environmental Protection Agency, August 1992.

Dufresne-Henry, 1998. *Record Drawings for Water Main Extension to Notre Dame Academy.* Prepared for Tyngsborough Water District by Dufresne-Henry, Inc., July 1998.

Dufresne-Henry, 1998. *Record Drawings for Water Main Extension, Flint Pond Area.* Prepared for Tyngsborough Water District by Dufresne-Henry, Inc., July 1998.

Durgin, P.B., Godfrey, R. And Levitt, K., 1996. *Redox Gradients in Ground Water with Implications for Remediation, Charles George Landfill, Tyngsborough, Massachusetts.* Published in the American Institute of Hydrology, 1996. Pp. CPE11- CPE21.

Environmental Laboratory, 1987. *Corps of Engineers Wetlands Delineation Manual.* Technical Report &-87-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MI.

Lowell Regional Wastewater Utility (LRWU) Industrial Discharge Permit for the Site, No. 085. Prepared by the Lowell Regional Wastewater Utility. July 31, 1998.

Massachusetts Department of Environmental Protection (MADEP), 1995. *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act - A Handbook.* Produced by the Massachusetts Department of Environmental Protection Division of Wetlands and Waterways. Written by S. Jackson. Edited by K W. Peterson, R. W. Golledge, Jr. and R. Tomczyk.

Massachusetts Department of Environmental Protection (MADEP), 1995. *Massachusetts Threshold Effects Exposure Limits (TELs) and Allowable Ambient Limits (AALs) for Ambient Air.* Massachusetts Department of Environmental Protection, Office of Research and Standards and the Division of Air Quality Control. December 6, 1995.

Metcalf & Eddy, Inc. (M&E), 1995. *Five-Year Review, Charles George Reclamation Landfill, Final Report.* Prepared by Metcalf & Eddy, Inc., August 1995.

Metcalf & Eddy, Inc. (M&E), 1999. *Draft Work Plan , Second Five-Year Review, Charles George Reclamation Landfill, Tyngsboro, Massachusetts.* Prepared by Metcalf & Eddy, Inc., March 1999.

Persaud, D., R. Jaagumagi, and A. Hayton, 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario.* Ontario Ministry of Environment and Energy. August 1993.

Reed, P.B., Jr., 1988. *National List of Plant Species that Occur in Wetlands: Northeast (Region 1).* U.S. Fish Wildlife Service Biol. Report 88(26.1).

Sample, B.E., D.M. Opresko, and G.W. Suter, II, 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.* Prepared by Environmental Sciences Division, Oak Ridge National Laboratory. ES/ER/TM-96/R3.

Suter, G.W., II. and C.L. Tsao, 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision.* Prepared by Environmental Sciences Division, Oak Ridge National Laboratory. ES/ER/TM-96/R2.

TRC Environmental Corporation (TRC), 1990. *Emissions Testing of an Enclosed Flare at the Charles George Landfill Superfund Site, Tyngsboro, Massachusetts.* Final Report. Prepared for Roy F. Weston by TRC Environmental Corporation. March 1990.

TRC Environmental Corporation (TRC), 1996. *Long-Term Groundwater Monitoring Report, Charles George Reclamation Trust Landfill, Tyngsboro, MA.* Draft Report covering October 1993 - July 1996. Prepared by TRC Environmental Corporation for the U. S. Environmental Protection Agency, October 1996.

TRC Environmental Corporation (TRC), 1999a. *Draft Form I Analytical Data Sheets for June Surface Water and Sediment Event, Charles George Landfill Site, Tyngsboro, Massachusetts.* Submitted to the U.S. Environmental Protection Agency by TRC Environmental Corporation. September 1999.

TRC Environmental Corporation (TRC), 1999b. *Emissions Testing of an Enclosed Flare at the Charles George Landfill Superfund site, Tyngsboro, Massachusetts, Draft Final.* Submitted to Roy F. Weston, Inc., Manchester, NH, by TRC Environmental Corporation, Lowell, MA. March 1999.

U.S.Army Corps of Engineers (USACE), 1997. *Construct Sanitary Sewer line, General Plan (sheet 2 of 16).* April 1997.

U.S. Army Corps of Engineers (USACE), 1998. *Charles George - Dunstable Brook Sediments - Metals Results (Form I Data Package).* Submitted to the U.S. Environmental Protection Agency. September 24, 1998.

U.S.Army Corps of Engineers (USACE), 1999. *Interim Industrial User Permit, Permit No. 085 -- Monthly Monitoring Report for May 1999, Charles George Landfill Site.* Prepared for the Lowell Regional Wastewater Utility. June 24, 1999.

U. S. Army Corps of Engineers (USACE), 1999a. *Summary of Enclosed Flare Operations -- 12 Month O&M Period* (April 1998 to April 1999). Prepared by the USACE, New England District, North Central Resident Office.

U. S. Army Corps of Engineers (USACE), 1999b. *Analytical Data Sheets for Surface Water Sampled January 27, 1999.* Submitted to the U. S. Army Corps of Engineers (USACE), New England District, North Central Resident Office by Roy F. Weston. Analyzed by Matrix Environmental Group, Inc., February 2, 1999.

U.S. Environmental Protection Agency (U.S. EPA), 1983. *Record of Decision (ROD) I.* Prepared by the U.S. Environmental Protection Agency. December 29, 1983.

U.S. Environmental Protection Agency (U.S. EPA), 1985. *Record of Decision (ROD) II.* Prepared by the U.S. Environmental Protection Agency. July 11, 1985.

U.S. Environmental Protection Agency (U.S. EPA), 1988. *Record of Decision (ROD) III.* Prepared by the U.S. Environmental Protection Agency. September 29, 1988.

U.S. Environmental Protection Agency (U.S. EPA), 1991. *Structure and Components of Five-Year Reviews.* OSWER Directive 9355.7-02. May 23, 1991.

U.S. Environmental Protection Agency (U.S. EPA), 1992. *Operations and Maintenance Plan for Post-Closure Period, Charles George Landfill Site, Tyngsborough, Massachusetts.* No author or date identified. Included in the EPA Administrative Record as Break 8.3, 1/92.

U.S. Environmental Protection Agency (U.S. EPA), 1994. *Supplemental Five-Year Review Guidance.* OSWER Directive 9355.7-02A, EPA/540/F-94/004. August 1994.

U.S. Environmental Protection Agency (U.S. EPA), 1998a. *Preliminary Close Out Report (PCOR).* Prepared by Patricia Meaney, U.S. EPA, Office of Site Remediation and Restoration, September 25, 1998.

U.S. Environmental Protection Agency (U.S. EPA), 1998b. *Summary of Sediment Analytical Results for cPAHs, Charles George Landfill Site.* Memorandum from E. Stanley to M. McDonough, U.S. Environmental Protection Agency, October 7, 1998.

U.S. Environmental Protection Agency (U.S. EPA), 1988c. *Explanation of Significant Differences, Charles George Reclamation Trust Landfill Superfund Site, Tyngsboro, Massachusetts.* Prepared by the U. S. Environmental Protection Agency. May 1988.

U.S. Environmental Protection Agency (U.S. EPA), 1999a. *Final Report, Residential Indoor Air Study, Ashland, Massachusetts.* Prepared by the U.S. Environmental Protection Agency, Office of Environmental Measurement and Evaluation (OEME), Region 1. February 1999.

U.S. Environmental Protection Agency (U.S. EPA), 1999b. *Charles George Residential Well Database (latest entry date is May 1997).* Compiled by U. S. Environmental Protection Agency. Printout copy sent to Metcalf & Eddy September 8, 1999.

U.S. Environmental Protection Agency (U.S. EPA), 1999c. *Explanation of Significant Differences, Charles George Reclamation Trust Landfill Superfund Site, Tyngsboro, Massachusetts.* Prepared by the U. S. Environmental Protection Agency. September 29, 1999.

U.S. Environmental Protection Agency (U.S. EPA), 2000. *The Charles George Superfund Site: Record of Decision II - On-Site Wetlands Evaluation/Mitigation.* Memorandum from Elaine Stanley, U.S. EPA Region I RPM, to Administrative Record, January 26, 2000.

Roy F. Weston, Inc. (Weston), 1999. *Analytical Data Sheets for Residential Well Monitoring, Charles George.* Prepared for Roy F. Weston, February 11, 1999. No author identified.

FIGURES

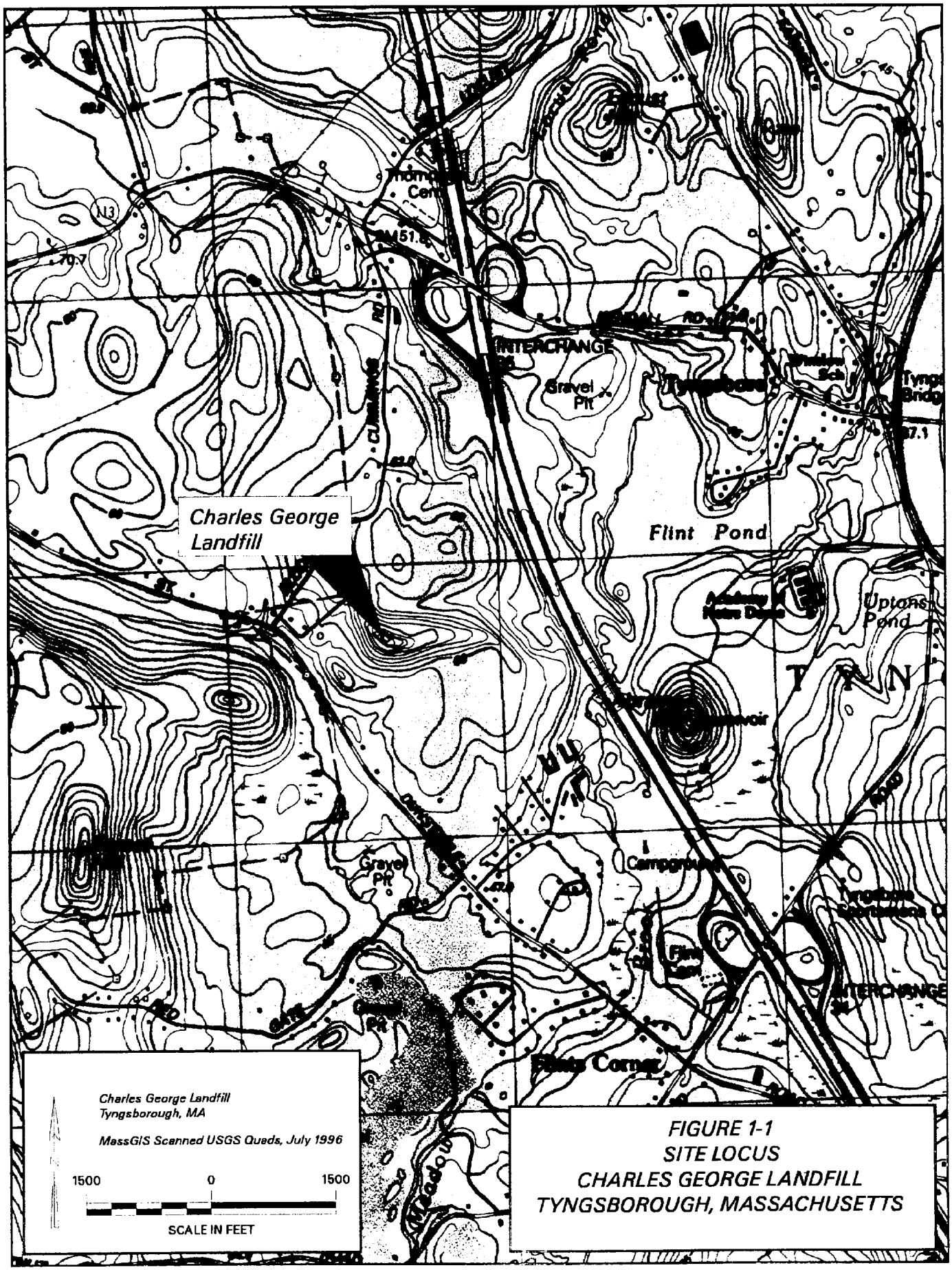

FIGURE 1-1
SITE LOCUS
CHARLES GEORGE LANDFILL
TYNGSBOROUGH, MASSACHUSETTS

EPA Region I New England
Superfund Document Management System

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Page # 57

Imagery Cover Sheet
Unscannable Item

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Site Name Charles George Land Reclamation Trust Landfill

Operable Unit 1, 2, 3, and 4

Break Number 8.3

Report or Document Title Figure 2-1. Five Year Review Site Layout

Date of Item 03-22-00

Description of Item Oversize Map

Number and Type of Item(s) 1

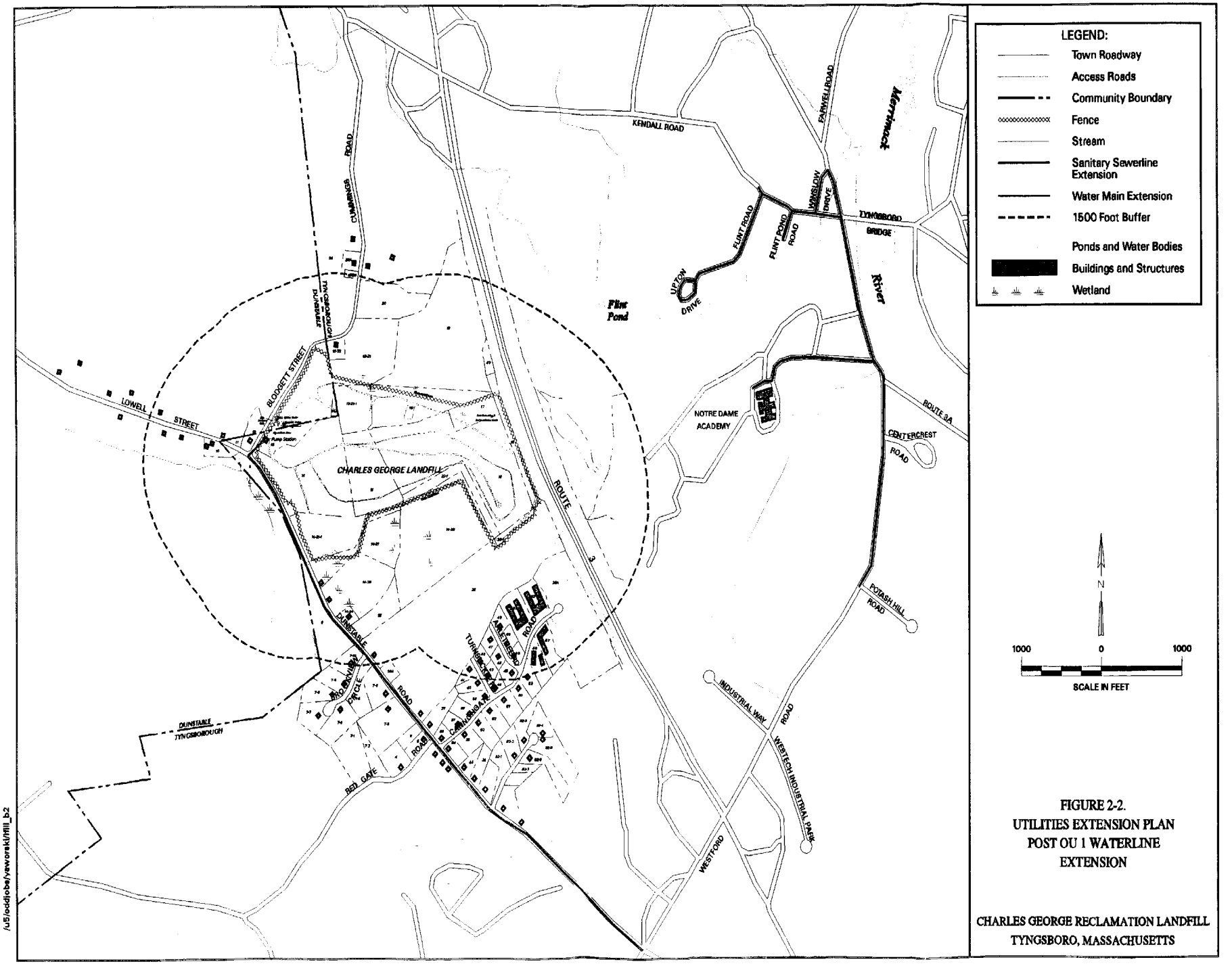

FIGURE 2-2.
UTILITIES EXTENSION PLAN
POST OU 1 WATERLINE
EXTENSION

CHARLES GEORGE RECLAMATION LANDFILL
TYNGSBORO, MASSACHUSETTS

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